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A Survey of Replica Consistency Maintenance Algorithms in Unstructured Peer-to-Peer Networks

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Abstract— Nowadays, Peer-to-Peer (P2P) networks have emerged as a promising architecture for file sharing. To achieve high performance and reduce the delayed response in file sharing, P2P networks make multiple copies of files and give share copies to some number of peers. The existence of multiple copies makes a problem as replica inconsistency. To address this issue many algorithms have been presented. In this paper, we review different types of replica consistency maintenance algorithms in unstructured P2P networks. The existing replica consistency maintenance algorithms suffer from high maintenance cost or redundant update message propagation and not guarantee network scalability. Thus it is essential to employ a strategy that can guarantee the replica consistency and improve the maintenance cost, number of update messages, availability and reliability in unstructured P2P networks.

Keywords— Unstructured Peer-to-Peer network; File sharing; Replica consistency; Update message.

I. INTRODUCTION

Peer-to-Peer networks have cached the most attention for computer networking on the Internet, particularly with file sharing. There are no centralized managements to share resources in these networks and each peer monitors its file sharing. The existing P2P networks are classified into two categories: structured and unstructured P2P networks on how the peers in the network are connected to each other. Structured networks consider a specific geometrical structure for networks and peers are arranged in a way that their locations are specified by a hash function. On the other hands, peers in unstructured networks are randomly connected to each other. For this reason, unstructured P2P networks have great potential for many research focus [1-5].

P2P networks employ data replication which leads data to be obtainable from many peers and subsequently to improve the system performance. Data replication is composed of making multiple copies of data, known as replicas, on separate peers. However, many studies focus on how to generate and distribute replicas, but difficulty of replication is how to keep replicas consistent. So, whenever a replica initiates an update, other replicas should be aware of the change and this goal is achieved by propagation of messages as update messages on the network. Hence different strategies are proposed to keep replica consistent in P2P networks. A proper strategy can significantly impact on the network performance [6-10].

The goal of this paper is to be focus on existing replica consistency maintenance algorithms in unstructured P2P networks. The rest of the paper is organized as follows. Section 2 presents replica consistency maintenance with its details. Section 3 presents various replica consistency maintenance algorithms and section 4 concludes the paper.

II. REPLICA CONSISTENCY MAINTENANCE

File availability increases by replicating it. However, replication causes a trade-off between availability and replica consistency maintenance. For read-only file there is no concerned about file replication, because a read operation on read-only file never changes file content and always returns the identical results. However, for writable file, when a user makes changes on one replica, the update content should be carried out on all replicas. Thus, one replica is updated, that replica becomes not the same as the rest, and hence update should be propagated to receive by all replicas to guarantee consistency. Update policies can be classified as group and master. Any peer can update its replica in group policy, but in master policy, only master updates its replica. The rest replicas are read only. In this paper, we study group policy in unstructured P2P networks [6, 11-15].

III. EXISTING REPLICA CONSISTENCY MAINTENANCE ALGORITHMS

File consistency maintenance is actually independent of file replication. Keeping replica consistent in a structured P2P network is achieved without great effort because placement of replicas is specified by a hash function. In unstructured P2P networks, the replica consistency maintenance alludes to the update message propagation on all the replicas of a file when one replica is updated [4], and hence many replica consistency maintenance methods have been proposed for unstructured P2P networks [16-19]. These methods can be divided into three according to how replicas inform from update files.

A. Update Strategies Based on Structure

These strategies use a certain data structure, a tree or a linked list to manage propagation of update messages in the network. Although, structured based methods reduce propagation of redundant update messages, high maintenance cost is against it [20]. Four algorithms are surveyed that proposed based on structure.

Wang et al. in their proposed algorithm created a logical chain (for each file one chain) collected of all peers which have a copy file to keep consistency (UPTRC). When a node initiates an update, it propagates update message to k online peers along both direction of the chain. The UPTRC algorithm dramatically prevents to propagate unnecessary update messages. However, it needs high overhead to maintain chain construction [4, 21, and 22].

Li et al., proposed a structure composed of two layers for consistency maintenance. The upper layer is Chord based and powerful and stable peers are selected to make this layer. The second layer consists of ordinary replica peers that connect to physically close upper layer peers. When an ordinary replica peer initiates an update, it is submitted to the corresponding upper layer peer and the corresponding peer dynamically builds a d-array tree on the upper layer by continuously partitioning the Chord identifier space. The update message is propagated in a top-down manner. The existence of the update tree is ended, after the update operation fulfils. This method ensures that each replica peer appears only once in UMPT, therefore can significantly reduce the redundant update. However, this method resorts to the upper layer peers, which leads not to be completely decentralized. Construction and destruction of tree is an overheating time and a cost-consuming work, especially in the P2P networks with high change rate [23 and 24].

Wang et al., used a logical group of peers as virtual servers (VRPS) to keep replica consistence. The peer which changes its replica, probes VRPS to detect online one, then transfers the update message to the online VRP as the MVRP. The MVRP sends the message to other VRPs to check conflict, if there is no conflict, the MVRP accepts and commits update message [22]. CMV minimizes the number of unnecessary update messages. However, selection of peers with high churn rate leads update propagation to become failure. Also, determination of the optimal number of VRPs and maintenance cost of them are important issue in this algorithm [23].

Toshiki et al., proposed a selective update propagation based on data update degree. This method consists of multiple trees, and replica peers with the same update condition form each tree. Each replica peer accepts the update if its update condition is satisfied. The update condition is the appropriate distinction between the original data and replica of peer. When a peer updates its replica, it sends the update only to the root peers which the difference between the updated data and their replicas are acceptable [25]. This approach do not guarantees consistency maintenance. Determination of best update condition for peers is difficult and incorrect value causes some peer never receive.

B. Update Strategies Based on Message Spreading

The strategies based on message spreading achieve high coverage rate, but suffer from redundant update message propagation and the amount of bandwidth consumed due to the maintenance messages would grow excessively as the network size increases [4 and 20]. In the following, three message spreading algorithms are studied.

Flooding is a simple technique based on broadcasting in replica consistency maintenance. When a replica initiates an update, it sends update message to all its neighbours, then the neighbours propagate the update message to all their neighbours. This technique has large coverage and is deterministic. However it greatly increases redundant update messages [26 and 27].

Xianfu et al. proposed an algorithm based on clone, variation and crossover operations that stores the update path information to reduce redundant update messages. Via clone operation, child peers share the update path information of theirs parents. Through variation operation peers add their IDs and their child peer IDs in path information. This algorithm additionally presented some peers as joint peers that use crossover operation to merge the path information of different paths [4]. Although, the paper archives high update success rate, but there are a lot of peers which can receive multiple duplicated update messages [20].

Meng and Zhang employed ant colony model for replica consistency maintenance. Ant updates replicas in its walking forward and updates file's pheromones in its returning process. When an update initiates in a peer, the peer create an ant, and then sends the ant to its neighbours. Peers update their replicas when receive the ant and then continue to send the ant to theirs neighbours. The ant comes back to the initiated peer, if the TTL (Time to Live) value becomes zero or the ant achieves the end of the paths. In an ant returning process, each peer update its file's pheromone by receiving the ant [16]. Determination of TTL is important in this paper. Also, the network scalability is not guaranteed by this strategy.

C. Update Strategies Based on Polling

Shen et al. proposed another approach that each replica peer polls its file owner or another peer to validate whether its replica is up-to-date, and updates its replicas accordingly. Briefly, each peer to determine autonomously the need to update a replica based on its file change rate. However, polling strategies reduce maintenance cost and prevent propagation of redundant update messages, their coverage rate is low and it is possible replica peers have different copies in a short time. GeWave [24] and IRM [28] are algorithms based on polling.

In IRM, each peer polls file owner or others replicas to validate its replica. IRM employed file change rate to determine poll time. The main issue of IRM in consistency maintenance is determination of the rate that a replica peer probes other replicas, and hence its coverage rate is low [4, 24 and 28].

GeWave structure is dynamically created based on the rate of polling peers. GeWave according to TTR (time to refresh), and the physical location of the peers considers a tree structure. Owner of the file is the root peer and other replicas based on theirs TTR levels are organized in ascending order from top to bottom. So that the peers at top of tree, have larger TTR than the peers on the bottom. The GeWave structure has L levels, where L is determined by the file owner according to the file query rate, TTR distribution, and an estimated number of replica peers. L should be set to an appropriate value. If L is too large, it will adversely affect the effectiveness of the GeWave structure for file updating. If it is too small, it may overload some peers with many children. In GeWave, each replica peer polls its parent for an update. After the original file is updated, the peers in the first level poll the file owner for updates before their replicas are queried. Later, the peers in the second level poll the peers in the first level before their replicas are queried, and so on [24].

IV. CONCLUSIONS

File replication in P2P networks improves availability and response time. Replica consistency maintenance is one of the key issues of file replication in P2P networks. In this paper, we have surveyed the various existing replica consistency maintenance algorithms in cloud computing. The existing replica consistency maintenance algorithms suffer from high maintenance cost or redundant update message propagations and not guarantee network scalability and coverage rate. Therefore there is a need to implement a replica consistency maintenance algorithm that can improve the coverage rate and reduce redundant update messages.

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